Temperature differences in two branches of the Maple River: The effects on fish and invertebrates.

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Abstract

The east and west branch of the Maple River in Cheyboygan and Emmet Counties differ in temperature. We hypothesized the warmer; East Branch would have a higher fish diversity and richness. We expected to find the same invertebrates in both temperatures with equal diversity, richness and abundance. On July 24th and 26, we sampled both rivers. We sampled fish with an electrofisher for 100 meters. Serber samplers and kick-nets were used to sample invertebrates. The substrate percentages were recorded as well as the temperatures. Phosphorus, nitrogen, alkalinity and pH samples were also taken. The East Branch and West Branch had very similar invertebrate diversities but the West Branch had greater fish diversity. The East Branch had a higher richness but a very low evenness. Salmonidae were only found in the colder West Branch due to low thermal tolerance. Only two species were found in both branches indicating the importance of temperature in determining community composition. Warmer temperatures led to higher fish species richness but didn't affect diversity. Habitat, phosphorus and discharge influenced species composition while the temperature had very little influence on invertebrate diversity, abundance and richness.

Introduction

Global warming has increased the temperature of the Earth 0.6ºC in the last century (Hansen et al. 1987). While this temperature change seems small, it can have detrimental effects on organisms that are thermally sensitive. Fish species are influenced by temperature and some fish families such as salmonidae are

temperature intolerant (Olla 1971). The distribution and abundance of fish species could therefore be altered by changing temperature.

Fish differ in preferred temperature ranges and therefore, will live in different habitats based on their tolerances. Families such as Salmonidae have low thermal tolerance ranges which would cause them to be found in cooler waters. The mean temperature where trout are found is 23.3ºC (Wehrly et al. 2007). In contrast, bluegill of the Centrarchidae family prefer 31.2ºC and therefore, we would expect them to be found in warmer waters (Beitinger 1977). The differences of fish temperature preferences will cause sensitive species to inhabit in thermally different water.

Due to different thermal preferences of fish, species will be found in different abundances depending on water temperature. Increasing temperature tends to lead to increased abundances and increased species (Henderson 2007). A 2ºC increase in seawater temperature led to 10% increase in fish richness in Bridgewater Bay (Henderson 2006). Warmer water tends to have a higher diversity (Franco-Gordo et al. 2003). Fish are poikilotherms and can not generate their own body heat. They must live in ranges of temperature that are not to cold for them to metabolize (Brett 1971). Therefore, less species will live in colder water due to metabolic needs.

While we expect to find different fish species in thermally different water, we do not expect to find different macroinvertebrate species with the exception of gastropods. According to a study by Feuchtmayr et al. (2007) the impact of temperature increase on macroinvertebrate abundances was low with only

gastropods increasing in heated waters. Diversity and richness are not dependent on temperature and are not altered with a temperature increase (Hogg et al. 1996).

To study the effects of possible temperature change, two branches of the Maple River were studied. One was the West Branch of the Maple River which has colder temperatures. It originates in Larks Lake via Brush Creek and Pleasant View Swamp. The East Branch has warmer temperatures than the west and originates in Douglas Lake and converges with the West Branch at Lake Kathleen. Due to the thermal differences, we hypothesize there will be a higher fish diversity, abundance and richness in the East Branch of the Maple River. Since invertebrate diversities and richness do not change with temperature, we hypothesize there will not be a difference between the East Branch and the West Branch.

Methods and Materials

We collected data at two branches of the Maple River. The West Branch has colder temperatures than the East Branch because they are fed from different sources, groundwater and Douglas Lake, respectively. We studied 100 meters to the north of Riggesville Road for the West Branch and 100 meters to the south of Douglas Lake Road for the East Branch. We measured temperature for each of the two days using a thermometer. Substrate, nutrients and discharge were measured to ensure the two branches did not have significant habitat differences due to factors other than temperature. Substrate was measured every ten meters for 100 meters. A tape measure was used to extend across the river's width. This allowed a cross section of 1 meter long and the river's width to be observed and

recorded. Water samples for alkalinity, total phosphorus, total nitrogen and pH were collected by filling three acid washed bottles to the brim. Stream velocity was measured with a current meter.

Both branches of the Maple River were sampled for invertebrates in two ways. A Serber sampler and kick nets were used to collect invertebrates by disturbing the substrate for 30 seconds. This was done three times. The specimens collected were placed in ethanol and identified to species or functional group at the lab using microscopes.

Fish were collected at both branches of the Maple River using an electrofisher for the 100 meters we studied. This was done on two separate days at the same time of the day. The species were identified and recorded in the field.

Results

The average water temperatures were 25.6º for the east branch and 16.5ºC for the west branch. The air temperature was an average 28ºC for both branches.

Statistical tests were used to look for substratum differences and all but two types of substrate had significant differences. The substrate for the west branch was composed mostly of sand while the East Branch had the highest composition of muck. There was significantly more weedy habitat in the East Branch (17.7%) compared to the West Branch (2.6%) (t-test, $T=-4.2$, $df=87$, $p<0.001$). There was also more other habitat in the East Branch (24.5%) than the West Branch (2.2%) (t-test, $T=-5.07$, $df=86$, $p<0.001$). The West Branch (52.9%) had significantly sandier habitat than the East Branch (23.4%) (t-test, $T=4.3$, $df=86$, $p<0.001$). There was not a significant difference between the East Branch (34.8%, 7.2%) and

West Branch (14.0%, 11.0%) for mucky and woody habitat, respectively (t-test, T=-1.64, df=84, p=0.1) (t-test, T=1.07, df=89, p=0.289).

None of the nutrients measured had a nutrient level outside the normal ranges. Alkalinity was highest in the West Branch of the river. It was 169.8 mgCaCO. versus 118.8 mg$CaCO_3$ in the east branch. Total phosphorus was 13.9 µg/L in the east branch and 6.1 µg/L in the west branch. Total nitrogen was 0.452 µg/L in the east branch and 0.441 µg/L in the west branch. Both the east branch and the west branch of the Maple River had a pH of 7.7. The discharge for the east branch was 1.12m^3/s and the discharge for the west branch was 3.03m^3/s.

The two branches of the Maple River studied had similar diversities and evenness but different compositions of functional groups. The diversity was 1.80 for the West Branch and 1.77 for the East Branch. The evenness for the West Branch was 0.72 and 0.74 for the East Branch. The East Branch had the largest composition of shredders (38%) as did the west branch (71%). The East Branch was much more evenly distributed among functional groups than the West Branch (Figure 1). There are a total of 13 different species in the east branch compared to 10 species in the west branch. Both branches had similar diversity and evenness but the East Branch had a higher richness.

The West Branch had a higher fish diversity and evenness but a lower richness. The fish species diversity was 1.37 for the east branch and 1.6 for the west branch. The evenness was 0.66 for the east branch and 0.89 for the west branch. The east branch had 8 species and the west branch had 6 species (Figures 2 & 3). The east branch had the largest percentages of hornyhead chubs

and common shiners with 54% and 18% respectively (Figure 2). The west branch had the largest percentages of slimy sculpins, mottled sculpin and brook trout with 25%, 29% and 20%, respectively (Figure 3). The brown, brook and rainbow trout were only found in the west branch as well as the slimy sculpin. The creek chub, the hornyhead chub, the common shiner, the mudminnow, the largemouth bass and the rock bass were only found in the east branch. The community compositions were very different among the two branches (Figure 4). Overall, the West Branch and the East Branch had different fish species, diversities, evenness and richness.

Discussion

The water temperatures had a 9.5ºC difference between the two branches. The change is enough to change organism composition and abundances (Olla et al. 1971). All but two fishes were only found in the cold or warm branch. The small amount of overlap illustrates fishes differ in thermal preferences.

The substrates were significantly different for every substrate except woody and mucky. This causes different compositions of invertebrates because of fundamental niche differences. Plecoptera and Ephemoptera prefer sandy habitats (Julka et al. 1999) so we would have expected to find more of those orders in the West Branch. We did find more Ephemoptera in the West Branch (2.85 per m^3) than the East Branch (0.06 per m^3) but we didn't find Plecoptera in either (Figure 5). Scrapers are more abundant in weedy habitat (Cummins 1979). The East Branch had weedier substrate and more scrapers (1.47 per m^3) than the West

Branch (0.46 per m^3). Due to differences in substrate, macroinvertebrates differed in functional group and order composition.

The west branch of the Maple River was the most buffered due to a high alkalinity. The east branch had the most phosphorus. Since phosphorus is usually the limiting nutrient in Midwest streams, the east branch is capable of higher productivity (Dodds 2002). Both of the phosphorus values were within the normal range for unpolluted streams (Wetzel 2001).The nitrogen concentrations were approximately the same for both branches. The pH was the same for both branches and therefore wouldn't cause a difference in species. 7.7 is within the normal range and is almost neutral.

Flow can affect the species found and their abundance. Ephemoptera and Diptera prefer faster water current (Julka et al.1999). The West Branch had a higher discharge than the East Branch and should therefore differ in composition. The West Branch did have higher abundances of Ephemoptera and Diptera with 2.85 & 0.34 per m^3 versus the East Branch's 0.06 and 0 per m^3. The different discharges led to different order compositions between the East and West Branches

Both branches had similar invertebrate diversity indexes as hypothesized. Gastropoda were not found in the colder west branch as expected because they prefer warmer temperatures (Feuchtmayr et al. 2007). The east branch had more species and it could be the result of higher concentrations of phosphorus because phosphorus limits primary productivity (Feuchtmayr et al. 2007). The lower levels of phosphorus in the west branch would limit periphyton growth and therefore, less

periphyton would be available for consumption. This would limit the scrapers in the west branch because they feed on periphyton. Substrate had an effect on invertebrate abundance and more Ephemoptera were found in sandy habitat. Flow also influenced species abundances. Diptera and Ephemoptera were present at higher abundances in the faster flowing branch. Flow, substrate and temperature all influenced invertebrate abundance but both branches had similar diversities and evenness. Therefore, composition was altered but not richness or evenness.

The only species found in both branches of the Maple River were the mottled sculpin and the brook lamprey. Brook lampreys prefer temperature ranges of 13-25ºC and both streams are in this general range (Lanteigne et al. 1981). The east branch was at the very top of the preferred temperature but streams have variation within the sediment and in pools. Slimly sculpins decrease in warmer waters but mottled sculpin do not (Lessard et al. 1971). This trend occurred in the Maple River because mottled sculpin were found in both branches but slimy sculpin were not. Trout were only found in the west branch of the Maple River because they prefer colder, flowing rivers (Wehrly et al. 2007, Zorn 2007). The temperature differences led to different community compositions with only two fishes being found in both branches.

The diversity of the west branch was larger than that of the east branch. This disproves our hypothesis. The east branch had a lower diversity and evenness. It had more species than the west branch but they were not evenly distributed. The horneyhead chub was extremely numerous. 157 out of 288 fishes were horneyhead chubs (Figure 5). There were very few bass and sculpins

present as well. The west branch has less species but the population is more evenly distributed among the sculpins, trout and lamprey. The only fish in extremely low numbers is the rainbow trout. We caught only one. Rainbow trout prefer temperatures in the range of 8.3-13.4ºC and the West branch had an average temperature of 16.5ºC (Barwick 2004). The thermal preference of the rainbow trout limited its abundance in the West Branch.

Substrate, discharge and temperature influenced the invertebrate composition but not the diversity or overall abundances of the thermally different branches of the Maple River. The temperature differences led to different fish communities. Salmonidae were only found in the West Branch because they prefer colder temperatures (Wehrly et al 2007). The West Branch had a greater fish diversity and lower richness. The East branch had a higher richness but a lower diversity due to uneven distribution of the species present. According to the results of our study, an increase in temperature due to global warming wouldn't affect fish diversity and richness as much as community composition.

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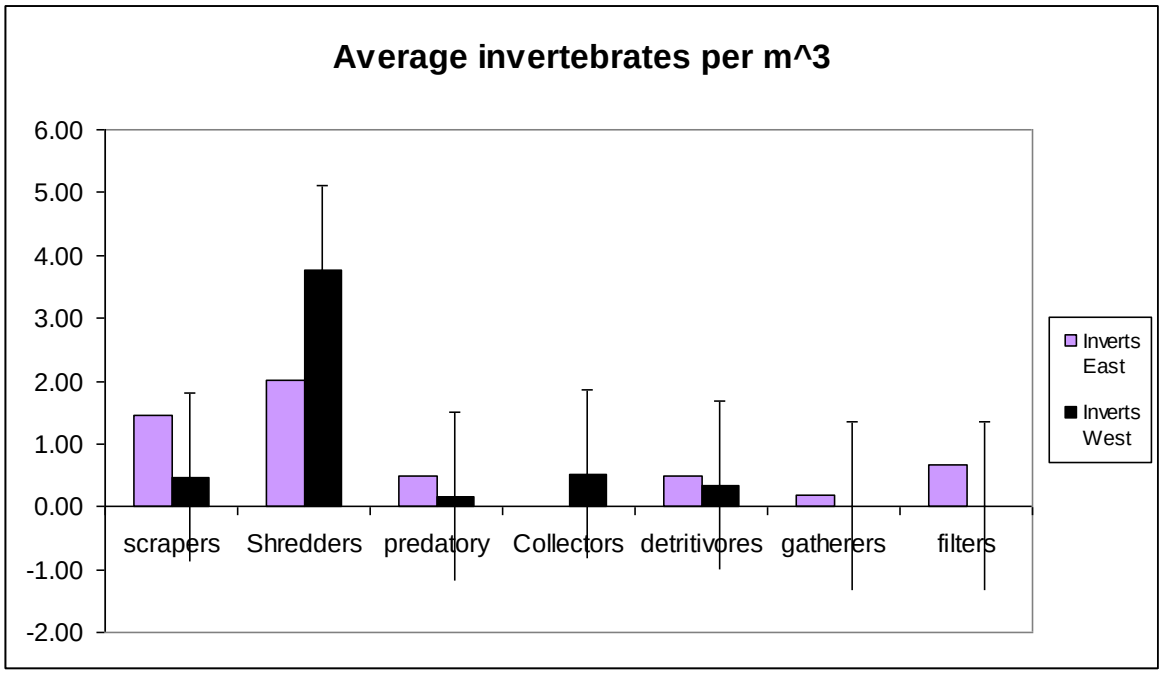

Figure 1- This table separates invertebrates by functional feeding group and the location they were found. The values are based on average found per m^3 with error bars based on standard deviation

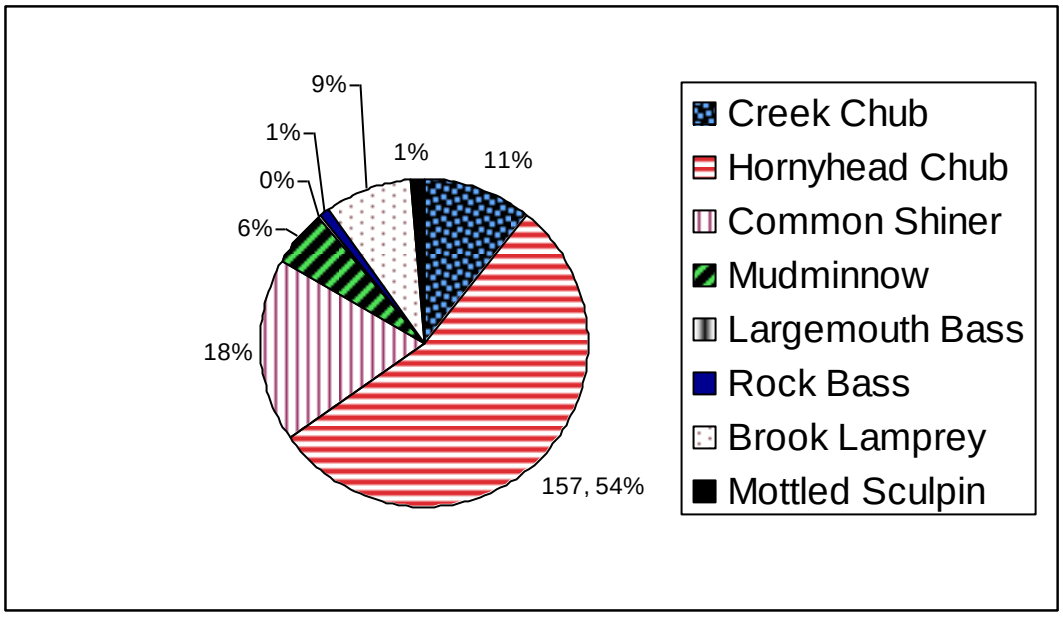

Figure 2- The fish species of the East Branch of the Maple River according to percentage. Horney head chubs are most abundant followed by common shiners

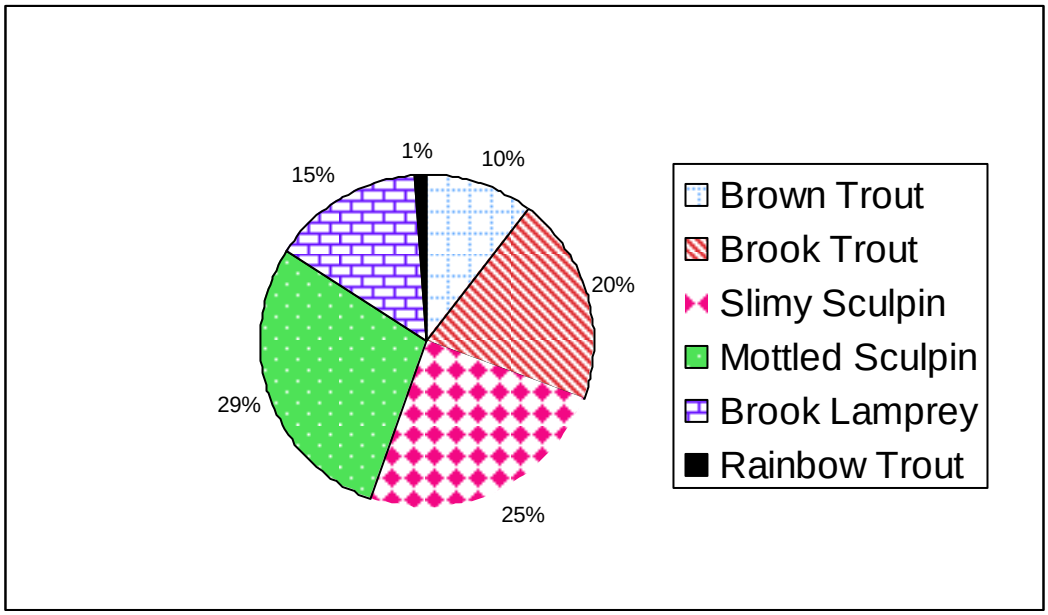

Figure 3- The fish species captured in the West Branch of the Maple River. The mottled sculpin and slimy sculpin were most abundant.

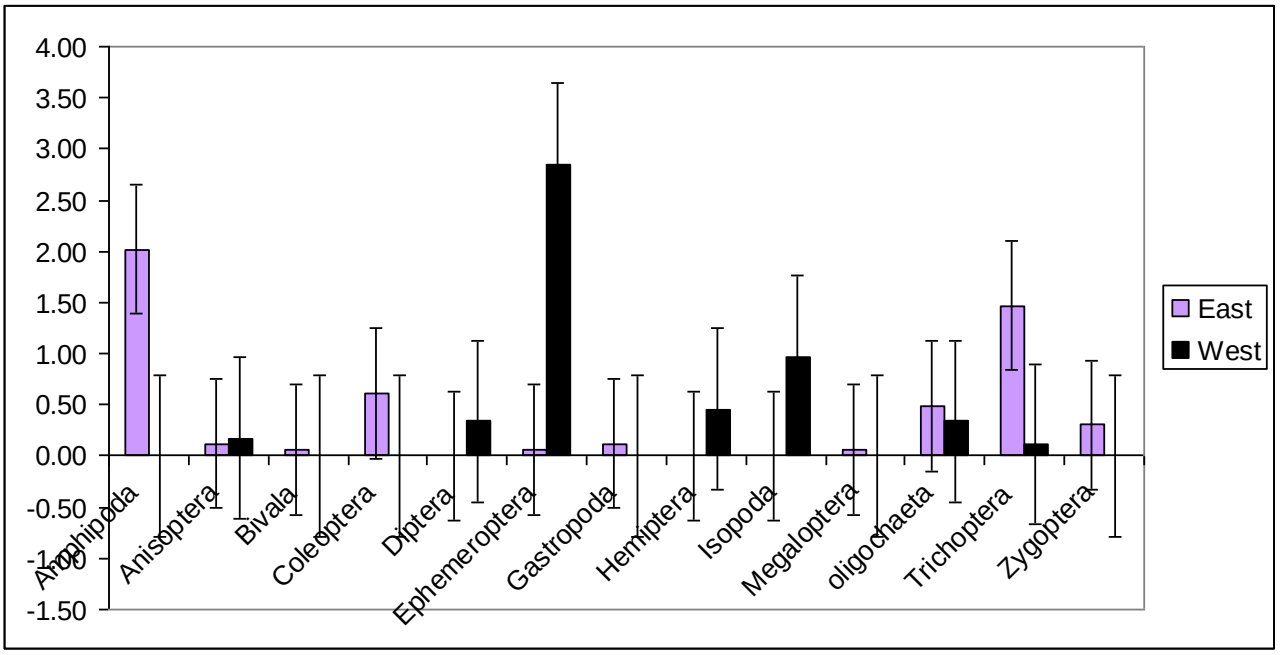

Figure 4- This bar graph separates the invertebrates collected by location and order. The values are the average number found per m^3. The error bars are based on standard deviation.

Figure 5- This is the community composition. There are three clusters because the warm branch and cold branch only had two species that overlapped.